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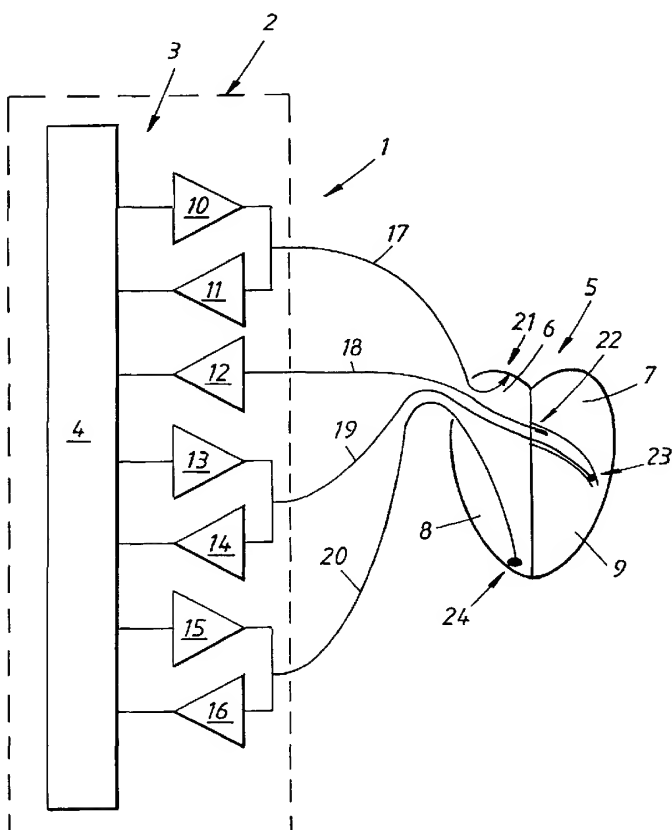
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*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

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(54) Title: A CARDIAC STIMULATING DEVICE



(57) Abstract: The invention concerns an implantable cardiac stimulating device (1). The device (1) comprises a pacing circuit (2) with means (13, 14) adapted to be connected to a first electrode (23) to stimulate and detect activity in the left ventricle. The control circuit (3) further comprises means (10, 11) and (12) to enable stimulation and activity detection in the right atrium (6) and to enable activity detection in the left atrium (7). At a spaced or sensed event in the right atrium (6) a first AV-delay is started. When the subsequent left atrial depolarization is detected by the detector (12) a new AV interval is started that will provide an optimized left side AV-interval. Either the left ventricle only or both ventricles are paced at the optimized left side AV-interval.

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## A cardiac stimulating device

### BACKGROUND OF THE INVENTION

#### 5           1.     Field of the invention

The present invention relates to an implantable cardiac stimulating device according to the preamble of claim 1. More precisely, the invention concerns a stimulating device having the capability to sense and stimulate the right atrium, to  
10   sense the left atrium, and to sense and stimulate the right and left ventricles respectively in accordance with the preamble of the main claim.

#### 2.     Description of the prior art

15   Most pacers are arranged to stimulate the right ventricle of the heart, but it is also known to stimulate the left ventricle. In particular for the treatment of congestive heart failure or other severe cardiac failures it is known to stimulate the left ventricle, or both ventricles, in order to  
20   optimize the hemodynamic performance of the heart.

US-A-5 720 768 describes different possible electrode positions in order to stimulate or sense the different chambers of the heart. It is also disclosed that the conduction time from right  
25   atrium to left atrium may be observed and the left atrium may be paced if the conduction time is too long.

It is wellknown in the art that it is difficult to position an electrode to pace and sense the left atrium. The problem to be solved by the invention thus is to provide a  
30   device alleviating these difficulties.

## SUMMARY OF THE INVENTION

5 This problem is solved with a pacemaker having the features of the characterizing portion of claim 1. The purpose of the present invention is to provide a cardiac pacemaker which provides an AV-interval which is optimized for the left side of the heart. A first AV-interval is started at paced or sensed events occurring in the right atrium. When the atrial  
10 depolarization has conducted to the left atrium this is sensed through an electrode located in the coronary sinus, preferably the proximal portion thereof. At the detection of the left atrial depolarization a second AV-interval optimized for the left heart is started. When this AV-interval has elapsed the  
15 left ventricle is stimulated with the left heart AV-interval. If no atrial event is detected on the coronary sinus electrode the initially started first AV-interval, AV1, will be used. Thus the AV-interval for the left side of the heart is optimized without any need for stimulating the left atrium.

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## BRIEF DESCRIPTION OF THE DRAWINGS

25 Fig 1 is a schematic representation of a device according to the invention connected to a heart;

Fig 2 is a schematic representation of a device according to the invention in which leads 18 and 19 have been integrated  
30 into one lead 25;

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig 1 shows an implantable cardiac stimulating device,  
35 hereinafter also called a pacemaker system 1, according to the invention. The pacemaker system 1 comprises a pulse generator 2 and leads 17, 18, 19, 20. A pacing circuit 3 is enclosed in the

pulsegenerator 2. The pacing circuit 3, and thereby the pulse generator is adapted to be connected to lead 19 with electrode 23. Fig 1 shows such an electrode 23 which is connected to the pacemaker via lead 19. The first electrode 23 is adapted to be positioned to stimulate the left ventricle 9 of the heart 5. The pacing circuit 3 is also adapted to be connected to a second electrode 22. Fig 1 shows such a second electrode 22 connected to the pacing circuit 3 via a lead 18. The second electrode 22 is positioned to sense depolarizations the left atrium of the heart 5. The pacing circuit 3 is further adapted to be connected to a third electrode 21. Fig 1 shows such a third electrode 21 connected to the pacing circuit 3 via a lead 17. The third electrode 21 is positioned to sense depolarizations the right atrium of the heart 5. A sensed or paced event originating from right atrial electrode 21 will start a first AV-interval. The first AV-interval, AV1, may be set to optimize the RA-RV contraction, the RA-LV contraction or the RA-both RV,LV contraction in the absence of a LA sense. In the normal case this right atrial depolarization will be conducted to the left atrium and be sensed by detecting means 12 via lead 18 and electrode 22. When the depolarization is detected at the left atrium the first ongoing AV-interval, AV1, will be superseded by a second AV delay, AV2, specifically optimized for the left side of the heart 5. This will provide a correct left side AV interval also if there is slow conduction from right atrium 6 to left atrium 7. In the case that no P-wave is detected from left atrial electrode 22 then said initially started first AV-interval will be used. At the end of the first AV-interval, AV1, a stimpulse is delivered to the left ventricle via lead 19 and electrode 23. The leads 17, 18, 19 and 20 may include more than one electrical conductor in order to allow for bipolar pacing and sensing. In that case electrodes 21, 22, 23, and 24 will have two active surfaces each.

In a preferred embodiment the system also comprises a lead 20 with electrode 24 for stimulation of the right ventricle 8 and for detection of R-waves from the right ventricle. In that

case the right ventricle may be paced with an AV-delay optimized for the right heart and the left ventricle may be paced with an AV-delay optimized for the left heart. Alternatively both ventricles are paced synchronously with an AV-interval optimized for the left ventricle.

According to an alternative embodiment as shown in fig 2 leads 18 and 19 are integrated into one lead 25 comprising electrodes 23 and 22 for placement in left ventricle and left atrium respectively.

In still another embodiment differential sensing is applied between electrodes 23 and 22 and discrimination between left ventricular P-waves and R-waves is accomplished through analysis of timing and morphology of the differential signal. This sensing concept is described in US-A-5 571 143 and in US-A-5 871 507 which are hereby incorporated by reference.

In still another embodiment the left atrial contraction is detected as a Far-Field P-Wave, FFPW, by sensing means 14 via lead 19 and electrode 23. Morphology discrimination may be applied to discriminate between left ventricular R-waves and FFPW as described above. Upon detection of a FFPW the ongoing AV-interval is superseded by the second AV-delay, AV2, that is started to provide an AV-delay optimized for the left side of the heart.

In a further refinement individual timing is provided for pacing the right and left ventricles. Right ventricle stimulation is delivered after the first AV-interval, AV1 has elapsed. The second AV-interval, AV2, which is started at the detection of a left atrial depolarisation determines when the stimulation pulse shall be delivered to the left ventricle. If no left atrial depolarisation is detected, the stimulation of the left ventricle is coordinated with the stimulation of the right ventricle.

The present invention is not limited to the above-described preferred embodiments. Various alternatives, modifications and equivalencies may be used. Therefore, the above embodiments should not be taken as limiting the scope of the

invention, which is defined by the appendant claims.

Claims

1. An implantable cardiac stimulating device (1),  
5 comprising:

a housing (2), a pacing circuit (3) and leads (17, 18,  
19, 20,)

said pacing circuit (3) comprising a control circuit (4) and  
stimulating output means (10, 13, 15) and amplifying and  
10 sensing means (11, 12, 14, 16) for sensing cardiac  
depolarizations, said pacing circuit (3) being adapted to be  
connected to a first electrode (23) to be positioned to  
stimulate and sense depolarizations in the left ventricle (9)  
of the heart (5), said pacing circuit being adapted to to be  
15 connected to a second electrode (22) to be positioned to  
sense depolarisations of the left atrium, said pacing circuit  
being adapted to be connected to a third electrode (21) to be  
positioned in the right atrium (6) adapted to stimulate and  
sense depolarisations, characterized in that a sensed  
20 depolarization of the right atrium (6) starts a first AV-  
delay, AV1, said first AV-delay being superseded by a second  
AV-delay, AV2, optimized for the left side of the heart upon  
the sensing of a left atrial depolarization by the left  
atrial detection means (12).

25 2. An implantable cardiac stimulating device (1) according  
to claim 1, characterized in that said pacing circuit  
(3) comprises means (16) for detection of right ventricular  
depolarisations and means (15) for stimulation of the right  
30 ventricle.

3. An implantable cardiac stimulating device according to claim 2, characterized in that the right ventricle (8) is stimulated simultaneously with the left ventricle (9).

5 4. An implantable cardiac stimulating device according to claim 2, characterized in that the right ventricle (8) is stimulated with an AV interval optimised for the right heart started on a right atrial depolarisation and that the  
10 left ventricle (9) stimulated with with a left heart AV interval started on detection of a left atrial depolarisation, and if no left atrial depolarisation is detected, the stimulation of the left ventricle is coordinated with the stimulation of the right ventricle.

15 5. An implantable cardiac stimulating device (1) according to anyone of the preceding claims, characterized in that anyone of electrodes (21), (22), (23) and (24) are bipolar.

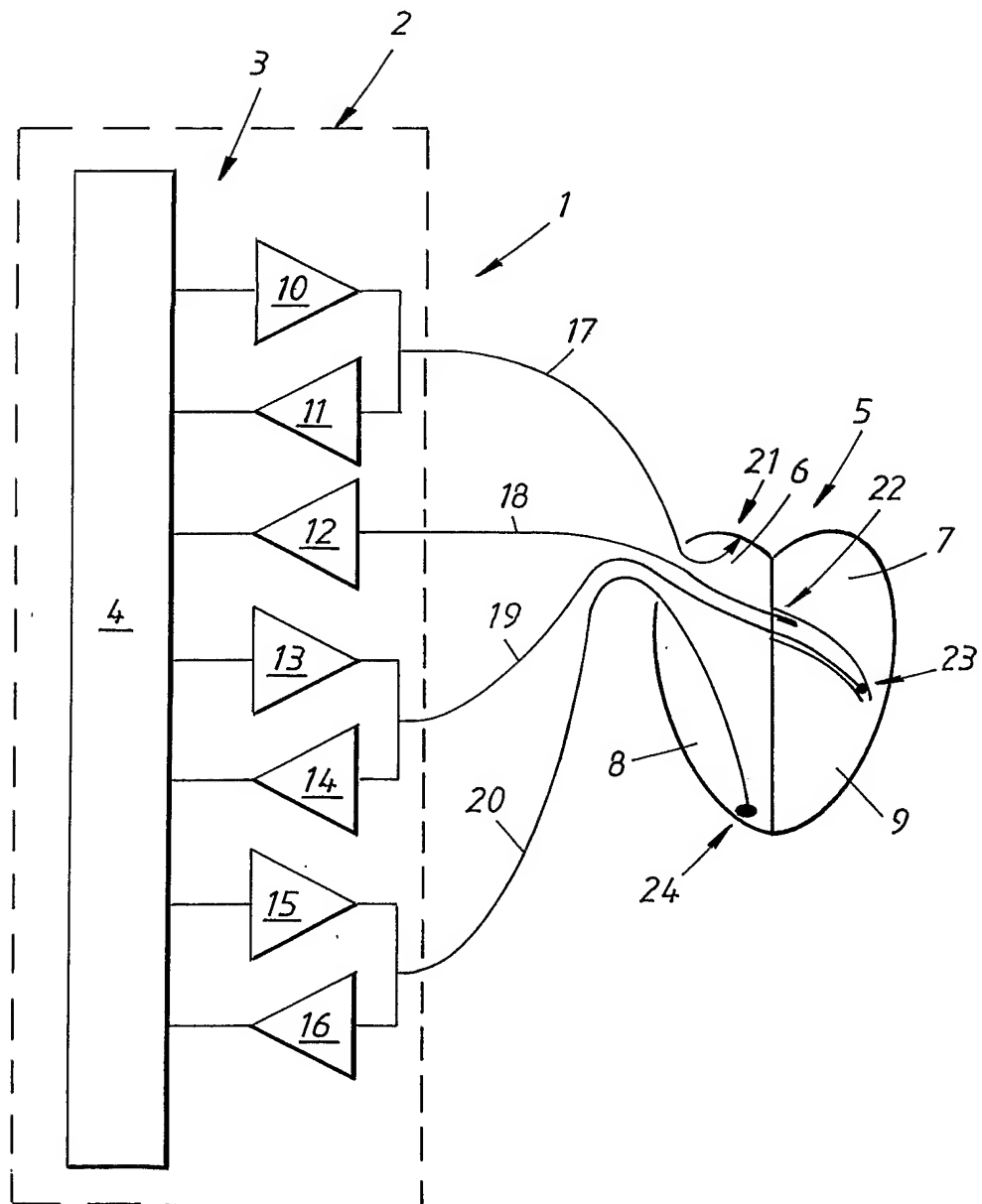
20 6. An implantable cardiac stimulating device (1) according to anyone of the preceding claims characterized in that left atrial depolarisations are sensed as FFPW on signals picked up by an electrode (23) located on the left side of the heart.

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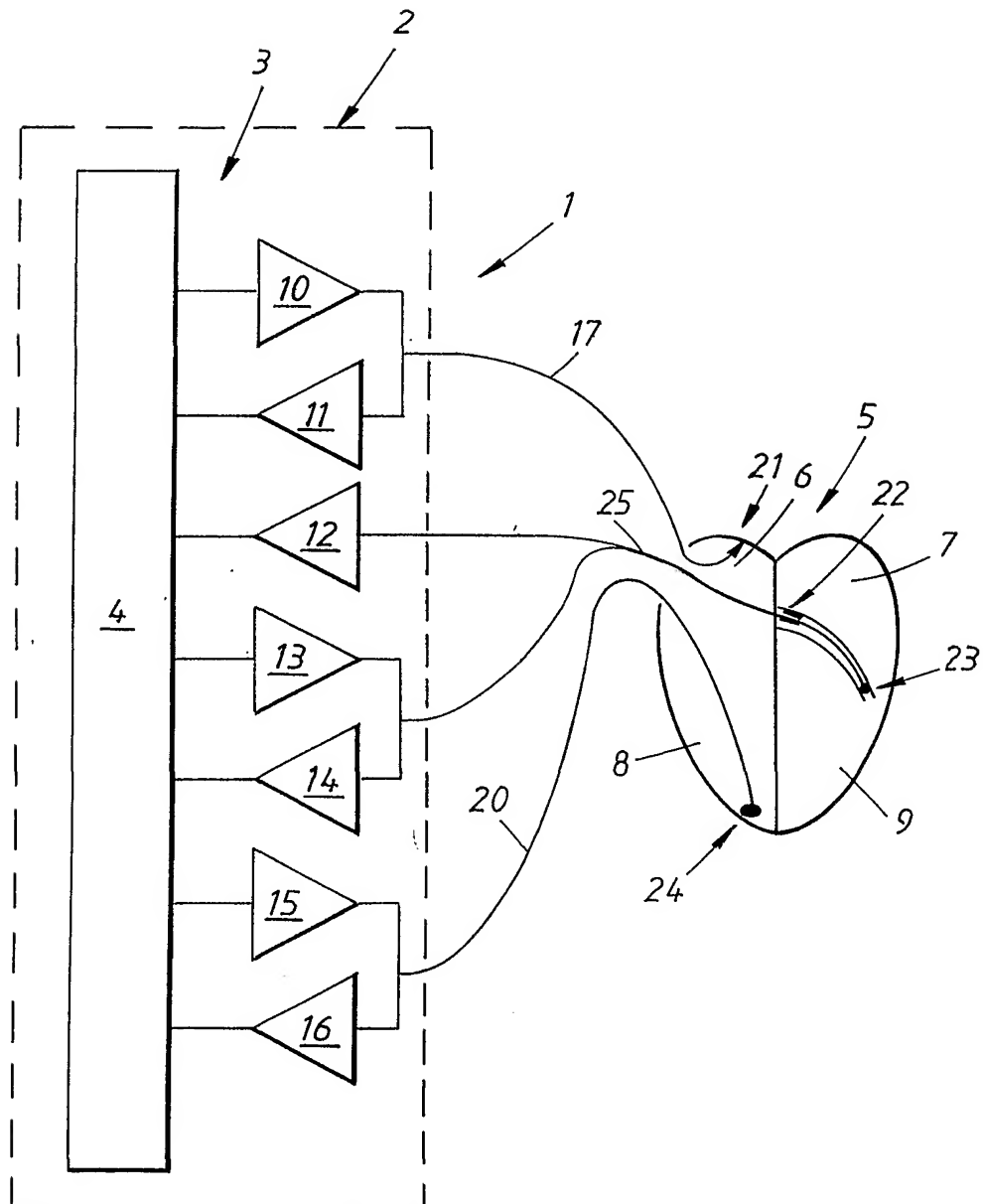
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Fig. 1



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Fig. 2



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 01/02548

## A. CLASSIFICATION OF SUBJECT MATTER

IPC7: A61N 1/368

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: A61N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

BIOSIS, EPO-INTERNAL, WPI DATA, INSPEC

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

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| A         | US 4856524 A (ROSS G. BAKER, JR.), 15 August 1989<br>(15.08.89), column 3, line 17 - line 34<br>--  | 1-6                   |
| A         | US 5720768 A (Y. VERBOVEN-NELISSEN),<br>24 February 1998 (24.02.98), column 2,<br>line 31 - line 44<br>--   | 1-6                   |

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

\* Special categories of cited documents:

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"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&amp;" document member of the same patent family

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## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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| A         | <p>PACE, Volume 23, No II, November 2000, Ho P-C et<br/>al., "Effects of Different Atrioventricular<br/>Intervals During Dual-Site Right Atrial Pacing on<br/>Left Atrial Mechanical Function" page 1750,<br/>column 2, line 48 - line 57</p> <p>-----</p> | 1-6                   |

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Information on patent family members

28/01/02

International application No.

PCT/SE 01/02548

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